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Improved Gabor filters for textile defect detection

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Abstract

In order to solve the problem of automated defect detection for textile fabrics, we studied the application of advanced computer image in this paper. A new method for defect detection using improved Gabor filters is proposed in this study. The experiment is completed by the improved Gabor filters which are two scales and six orientations. A variety of samples of fabric inspection are presented. The experimental results obtained further confirm satisfied performance and the low computational requirement. Online implementation is possible owing to its simplicity.

Keywords: Gabor filters; Guass filers; cost function; defect detection;

1. Introduction

A greater product variety and shorter life cycle for production have been generated by the continually changing fashion of garments. A larger proportion of the total cost of production in garment manufacturing is constituted of textile fabrics. Since flaws in fabrics may reduce the price of a product by 45%-65% [1], quality control of fabrics plays a crucial role in the garment manufacturing industry. It is reported that the detection of defects in textile fabrics prior to any manufacturing process is usually performed by human inspectors with an accuracy of about 60%-70% [2]. That's because human inspection has some deficiencies. Now, there are some detection systems of commercial products, such as I-TEX inspection system available from Elbit Vision Systems, Barco Vision's Cyclops and Zellweger Uster's Fabriscan. It is noted worth I-TEX inspection system available from Elbit Vision Systems, which can

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detect fabric at the speed of 100m/min [3]. However, each of inspection system has its own deficiencies, and defect detection is limited to a part of defects.

In recent years, various approaches for defect detection have been proposed. Zhang and Bresee [4] combined morphological operators and autocorrelation functions to inspect two types of fabric defects. Campbell et al. [5] used the model based clustering method to detect linear pattern production defects, and Ozdemir and Ercil [6] used Gauss Markov random fields to detect common defects in textile fabrics.

Here we present a new approach for automatic detection in textile, based on two scales and six orientations Gabor scheme that are suitable for detecting different scale flaws. The proposed method is an effective way to solve the filter parameter selection problem for fabric defect detection. And the method would automatically segment defects from the regular texture.

2. The improved Gabor filters and defect detection

Each of traditional Gabor filters has the real and imaginary parts. The real and imaginary parts of all Gabor filters are implemented as an M×M convolution mask. Generally speaking, M often chooses an odd number.

The Gabor function is modulated by a two-dimensional Gauss function which is translated in two axis of frequency in the spatial. The improved Gabor filter in two-dimensional plane has the following general form [7].

$$g(x,y) = [-{(x'^2+y'^2)}/{2\sigma_{xy}^2}] \times [\exp(2\pi jfx') - \exp(-{f^2}/{2\sigma_{uv}^2})] / 2\pi\sigma_{xy}^2 \tag{1}$$

Where

$$\begin{cases} x' = x\cos\theta + y\sin\theta \\ y' = -x\sin\theta + y\cos\theta \\ \sigma_{uv} = \dfrac{1}{2\pi\sigma_{xy}} \end{cases} \tag{2}$$

The space constants σ_{xy} defines the Gauss variance along the x and y axes, f controls the frequency of filters, θ determines the scale of filters. The parameters *(u, v)* define the spatial frequency of a sinusoidal plane wave, which can also be expressed in polar coordinates as radial frequency f and orientation θ :

$$\begin{cases} f^2 = u^2 + v^2 \\ \tan\theta = \dfrac{v}{u} \end{cases} \tag{3}$$

This paper investigated defect detection by using a group of Gabor filters $g_n(x, y)$, $n=1, 2, 3\ldots, P \times Q$, P denotes the total of scale, Q denotes the total of orientation. For a picture of the input images $I_i(x, y)$, the magnitude of filtered image $I_n(x, y)$ is gained by using $g_n(x, y)$ as follows:

$$I_n(x, y) = \{[g_n(x, y)_r * I_i(x, y)]^2 + [g_n(x, y)_i * I_i(x, y)]^2\}^{0.5} \tag{4}$$

where $g_n(x, y)_r$ and $g_n(x, y)_i$ are real and imaginary components of $g_n(x, y)$, respectively. '*' denotes 2-D convolution.

Fabric flaws can have greatly response to some orientations and scales of Gabor filters. Therefore, this paper uses an effective approach which is proposed by Kumar [8] to choose an optimal output and describe the flaw. First, we can gain some images and divide them into N nonoverlapping square regions by inputing an image, applying $P\times Q$ Gabor filters. This step is different from Kumar's. Secondly, to find the maximum value T^i_{max} and the minimum value T^i_{min}, the mean of output amplitude for each square region were calculated. A cost function $K(i)$, which weighs all output. Thirdly, the equation (5) determines the output which is an optimal one and is denoted as $I_{best}(x, y)$.

$$K(i) = \left(\frac{T^i_{\max} - T^i_{\min}}{T^i_{\min}}\right) \tag{5}$$

The experiment gains the image containing noise, applying Gabor filters. The experiment used Guass filters to reduce the speckle-like noise.

Before binarization, it must make sure the thresholding limits which can be gained from the normal samples. Of course, the normal samples must be disposed by using the Gabor filters and Guass filters, to acquire the reference sample and denotes it as $B(x, y)$. The reference sample is used to determine the thresholding limits $\gamma_{\max}$ and $\gamma_{\min}$ [9].

$$\begin{cases} \gamma_{\max} = \max\limits_{x, y \in W} |B(x, y)| \\ \gamma_{\min} = \min\limits_{x, y \in W} |B(x, y)| \end{cases} \tag{6}$$

Where W is a window centered at the image. In order to avoid the distortion of convolution at the border, all the pixel come from the window. The experiment gains the binarization result from the equation (7).

$$D(x, y) = \begin{cases} 1 & B(x, y) > \gamma_{\max} or B(x, y) < \gamma_{\min} \\ 0 & \gamma_{\min} \le B(x, y) \le \gamma_{\max} \end{cases} \tag{7}$$

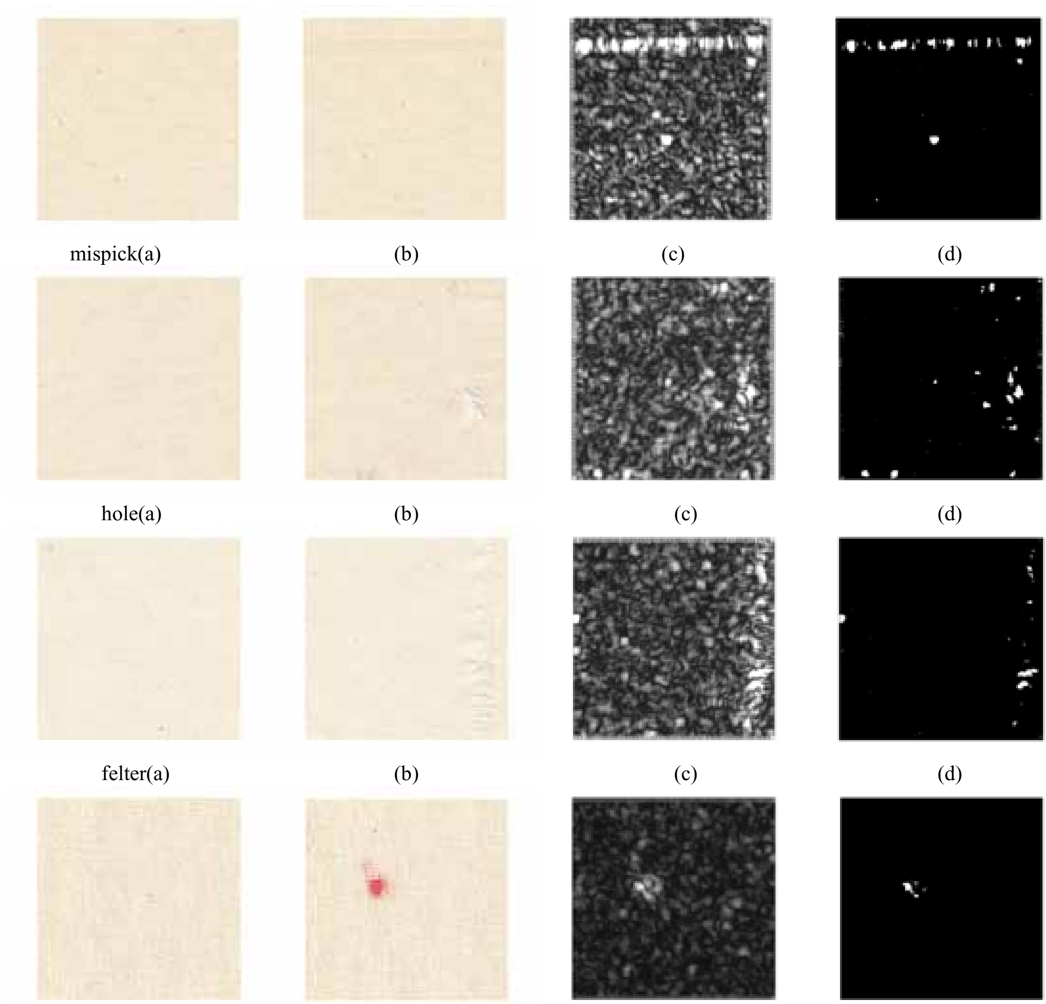
3. Experiments and results

In this experiment, all Gabor filters are implemented as an 11×11 convolution mask for their real and imaginary components. The group of Gabor filters are two scales f and six orientations 错误！未找到引用源。, $f = 2$^L/4 L= 0, 1, $\theta = \pi(n+1)/6$ n = 0, 1, 2, 3, 4, 5, and the mask size of the Guass filter is 3×3. We used the flaw samples which are mispick, hole, felter, inkblot and shuttle mark. The optimal orientation, scale of Gabor filter and the maximum value of cost function about the five kinds of defect samples are showed in Table 1.

Table 1 The optimal orientation, scale of Gabor filter and the maximum value of cost function

	mispick	hole	felter	inkblot	shuttle mark
Kmax	0.4829	0.5146	0.7707	0.6175	0.6395
f	1/4	1/4	1/4	1/2	1/4
θ	$2\pi/3$	$\pi/3$	$5\pi/6$	$5\pi/6$	$\pi/3$

Fabric samples with different fabric defect are displayed in Fig. 1.



mispick(a) (b) (c) (d)

hole(a) (b) (c) (d)

felter(a) (b) (c) (d)

inkblot(a) (b) (c) (d)

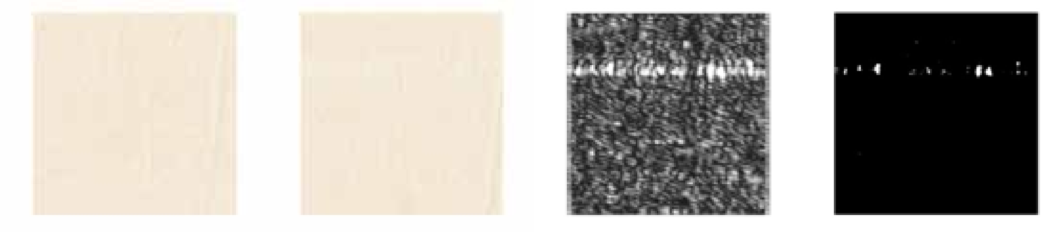


Fig. 1 Fabric sample images with different types of defects, and the final defect detection results obtained by using the proposed scheme, (a) normal samples, (b) flaws, (c) applied the Gabor and Guass filters results, (d) the final defect detection results

4. Conclusion

In this paper, we used a group of improved Gabor filters to detect the flaws. The experimental results obtained further confirm satisfied performance and the low computational requirement. It indicated that the algorithm is very well. However, the method is not suitable for all textile flaws, and the improvement about it would be our future work.

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